

**Naval Submarine Medical Research Laboratory**

**NSMRL Special Report #06-02**

**26 September 2006**



**COMMAND HISTORY  
OPNAV 5750-1  
FISCAL YEAR 2005**

Jerry C. Lamb, Ph.D., Heather M. Huebner, and Maria P. Fitzgerald Editors

Naval Submarine Medical Research Laboratory

Released by:  
J. C. DANIEL, CAPT, MC, USN  
Commanding Officer  
NavSubMedRschLab

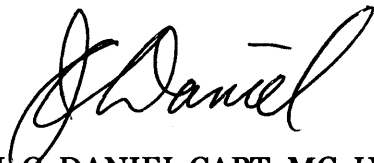
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Approved and Released by:

A handwritten signature in black ink, appearing to read "J. Daniel", written in a cursive style.

J.C. DANIEL CAPT, MC, USN  
Commanding Officer  
NAVSUBMEDRSCHLAB

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## **ABSTRACT**

**This is the Command History, OPNAV 5750-1, for the Naval Submarine Medical Research Laboratory for Fiscal Year 2005.**

## **ADMINISTRATIVE INFORMATION**

**This report was approved on 26 September 2006 and assigned Special Report Number 06-02.**

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COMMAND HISTORY  
Fiscal Year 2005  
Part 1

**1. Basic Historical Narrative**

**a. Command Mission**

The Naval Submarine Medical Research Laboratory's (NSMRL) mission is to protect the health and enhance the performance of our war fighters through focused submarine, diving, and surface research solutions. Established in World War II, NSMRL was originally responsible for selecting personnel for training at the Submarine School, conducting specialized training in submarine medicine for Hospital Corpsmen and Medical Officers, and researching medical aspects of submarines and diving. Today, NSMRL continues to be the biomedical R&D leader in submarine medicine, health effects of submarine atmosphere constituents, auditory sonar information processing, selection/qualification of submariners, escape and rescue from disabled submarines, diving bioeffects, and hearing conservation technology.

**b. Command Staff**

Commanding Officer: CAPT J. C. Daniel, MC, USN

Executive Officer: LCDR T. C. Herzig, USN

Technical Director: J. C. Lamb, Ph.D.

Departments:

Submarine Medicine & Survival Systems	W. G. Horn, MD
Diving & Environmental Simulation	E. A. Cudahy, Ph.D.
Human Performance	LCDR L. Crepeau USN
Resources	HMCS(SS) M. Napolitano, USN

**c. Facilities:**

(1) Located on the Naval Submarine Base New London, Groton, CT, NSMRL researchers have access to three Attack Submarine Squadrons in Submarine Group Two, the Naval Submarine School, the Naval Submarine Support Facility, the Naval Undersea Medical Institute, and many more submarine support activities. One mile down the Thames River is the Electric Boat Division of General Dynamics, builder of all classes of U.S. nuclear submarines. Several colleges and universities are nearby, including the U.S. Coast Guard Academy, Connecticut College, and the University of Connecticut. NSMRL's three multi-disciplinary research departments use highly capable facilities including three hyperbaric chambers, anechoic chambers, auditory and vision laboratories, closed atmosphere test room,

diving boat, technical library, and NUWCs Dodge Pond Open Water Diving and Sonar Test facility.

(2) Capabilities:

- 3 Hyperbaric Chambers (1 Saturation)
- 1000m<sup>3</sup> Anechoic Chamber
- 140m<sup>3</sup> Reverberant Chamber
- 10 Audio Testing Booths
- Vision Research Suites
- Closed Atmosphere Test Room
- Diving Work Boat
- Technical Library

(3) Floor Space:

- |   |              |              |
|---|--------------|--------------|
| • | Building 148 | 6,480 sq ft  |
| • | Building 141 | 19,930 sq ft |
| • | Building 156 | 17,952 sq ft |

d. Mission Accomplishments by FY05 Research Work Unit

**Submarine Medicine & Survival Systems Department**  
**W. G. Horn, MD, USNR, Dept. Head**

**Work Unit #5903**

**Title:** Study on Prediction of Submarine Service Disqualifications

**Principal Investigator:** J. Whanger

**Accomplishments** (FY05):

In January 2005, preliminary analyses were performed, and indicated that the Millon Clinical Multiaxial Inventory, which is the "off the shelf" assessment of psychopathology originally used by Christine Schlichting in this study, has the potential to predict variance (i.e., an additional 20% of the variance) in Submariner attrition above and beyond the variance in attrition predicted by SUBSCREEN's Submarine Attrition Risk Test (SMART) ( $F(1,35) = 9.983$ ,  $p < .01$ , with Delta R-squared = .20, Total R-squared = .29, and Multiple R = .54). A larger sample is still needed, but if this outcome replicates with a larger sample size, then we would certainly conclude that the Millon is a value-added instrument when combined with SUBSCREEN for predicting attrition in the Submarine Force (SUBFOR).

**Work Unit #50303**

**Title:** Pulmonary Function Screening of Submarine Personnel Prior to Pressurized Submarine Escape Training, and Development of Lung Function Standards

**Principal Investigator:** Surgeon Commander P. Turnbull, Royal Navy

**Accomplishments** (FY05):

Approval to approach the Naval Submarine School (NAVSUBSCOL) students to request their participation as subjects was obtained from the Commanding Officer of NAVSUBSCOL. Unfortunately, due to a change of command at the NAVSUBSCOL this approval was delayed by approximately 8-10 weeks. Discussions with NAVSUBSCOL identified the submarine escape training building to be the most efficient and convenient venue for mass spirometry to take place. As of Jan 2005, 2,000 subjects have been tested. Although a smaller number than anticipated, this is due to fewer subjects passing through NAVSUBSCOL than predicted, sufficient data has been collected to commence analysis and production of predicted values. Data collection will continue while data analysis commences.

**Work Unit #50402**

**Title:** Submarine Attrition Risk Test (SMART)

**Principal Investigator:** J. Whanger

**Accomplishments** (FY05):

This project began in the first quarter of fiscal year 2004. Accomplishments can be summarized as follows:

- The SUBSCREEN program was improved and modified to generate individual SMART (formerly SARS) results.
- The level of risk and randomization protocol was programmed and automated.
- The behavioral and academic outcomes acquisition program was created and tested.
- The IRB protocol NSMRL 2004.0005 was written and, after revision, approved.
- The overall intervention activities list was created and reviewed by NAVSUBSCOL.
- The BESS student cohort was identified and endorsed by NAVSUBSCOL N6.
- One of two white papers transitioned to a NSMRL Memorandum Report #05-01.
- The experimental phase began on 20 July 2004.
- As of February 2005, approximately 688 Basic Enlisted Submarine School (BESS) students have volunteered for the study protocol. Of these volunteers, 254 were found to be 'at risk' for attrition according to SUBSCREEN's SMART and thus eligible for entry into the study protocol. These 254 volunteers were subsequently matched on the SMART for level of attrition risk, and randomly assigned to experimental (n=130) versus control (n=124) groups.

One finding to date that is of scientific interest in terms of the ultimate generalizability of this study's results is the fact that 45% of those who do not volunteer for the study are found to be 'at risk' for adverse attrition by the SMART, which is in contrast to the fact that 37% of those who do volunteer for the study are found to be 'at risk' for adverse attrition by SMART. If this trend continues throughout the study, then it may attenuate the generalizability of the study's results to the extent that conclusions about the effect of SMART-based interventions on the performance and retention of volunteers (n=688) are not applicable to non-volunteers (n=590).

With respect to academic performance at BESS, we have been able to successfully track to date (17 Feb 2005) 116 BESS students who were entered into the study protocol as either control (n=62, M=82.53, SD=6.57) or experimental (n=54, M=81.82, SD=5.95) group members. Using an independent samples t-test to determine whether or not the difference between these means is statistically significant, we find  $t(114)=0.609$ ,  $p=.54$ . Clearly at present, the observed difference between these means is not statistically significant. This finding suggests that academic performance is unaffected by the SMART-based interventions. However, it may be unrealistic to expect individually-based interventions, all of which are performed within a short 5-week period (the length of BESS) and only some of which include additional academic aid and instruction, to change academic performance for the experimental group as a whole. Also, were the experimental group members to be overly stigmatized by the study protocol, then we might expect poorer academic performance from the experimental group in comparison to the control group, and this is not the case according to the current findings.

Although we have begun data analyses to test our primary hypotheses, current results are somewhat inconclusive because we do not yet have complete data for student outcomes (e.g., graduation status, instructor ratings, class grades, non-judicial punishment (NJP) events, etc.). Also, we are still acquiring misconduct data for members of both groups.

**Work Unit # 50403****Title:** Heat Stress**Principal Investigator:** W.G. Horn, MD**Accomplishments (FY05):**

The results of this study are being prepared as a technical report. Results have been briefed to the Submarine Escape and Rescue Working Group. Transition to the fleet will occur with incorporation of findings, information and recommendations into procedural documents that provide guidance to the DISSUB senior survivor and crewmembers. These documents include the Disabled Submarine Survival Guide (Guardbook).

NSMRL has worked closely with the fleet and involved activities during all phases of development. The recent NSMRL Fleet Review resulted in favorable comments and ratings for this project.

Estimated transition period: 2 years.

**Work Unit # 50407****Title:** SEE/RESCUE Distress Streamer**Principal Investigator:** W.G. Horn, MD**Accomplishments (FY05):**

During FY05, substantial progress on the Rescue Streamer project resulted in major findings and results. Funding permitted initiating purchase of the final order of streamers from Rescue Technologies. The streamers were evaluated in a major two-week, testing program in which contractors placed life vests and submarine escape rafts, with and without deployed streamers, at sea off Wallops Island, VA. Test search patterns and data collection performed in over 100 flight hours by Naval Air Station (NAS) Patuxent River P-3 and helo aircraft showed that the rescue streamer almost tripled the probability of finding a person in the water wearing a life vest over finding a person not using a steamer. In addition, sub escape rafts equipped with a deployed streamer were significantly easier to locate by Search and Rescue (SAR) forces. Using the collected data, the U.S. Coast Guard Research and Development Center calculated optimum search width patterns and guidance that will be forwarded and incorporated in national and international search and rescue publications. The SEE/Rescue streamers were also tested in actual submarine escape scenarios in which submarine escape trainees equipped with streamers performed escape from 100-foot depths in a submarine escape training tower, followed by a successful deployment of the streamer by the trainee in rafts. Streamers were also drift-tested in Long Island sound and showed successful deployment and performance over time. Performance data and results were briefed to the U.S. Navy Submarine Escape and Rescue Review Group at Commander Naval Submarine Force, Norfolk, VA, as well as the NATO Submarine Escape and Rescue Working Group at NATO Headquarters in Brussels, Belgium. In summary, project results in FY05 have demonstrated that the SEE/Rescue streamer is an effective SAR device that has the potential to significantly improve chances of survival and rescue at sea.

**Work Unit # 50501**

**Title:** SUBSCREEN

**Principal Investigator:** J. Whanger

In FY05 a new project was begun to help meet the Human Capital Strategy (HCS) agenda with the use of SUBSCREEN for Junior Officer prescreening. The project title is The Prediction of Submarine Officer Advance Course (SOAC) Ascendancy from SUBSCREEN Scores.

The HCS agenda helps the Navy predict which junior officers in SUBFOR are the most likely to ascend to SOAC. The product could be used for future force reduction initiatives while maintaining operational effectiveness. Statistical analyses have begun, and current results suggest that an aggregate of SUBSCREEN scale scores can predict ascendancy to SOAC (e.g., preliminary analyses indicate that Multiple R = .20,  $p < .001$ )

SUBSCREEN psychological screening operation is NOT a research program, but instead an official and ongoing Navy screening operation mandated by the MANMED (Article 15-69, para 2(i)) and formalized by NAVSUBSCOL Instruction 6420.1. NAVSUBSCOL Instruction 6420.1 also designates the NSMRL as the command responsible for SUBSCREEN administration, examination, scoring, and maintenance, etc.

**Work Unit # 50507**

**Title:** SURVIVEX

**Principal Investigator:** W.G. Horn, MD

**Accomplishments (FY05):**

A survival exercise (SURVIVEX 04) was conducted from 9-13 December 2004 onboard USS SALT LAKE CITY pier side at Point Loma Naval Base, San Diego, CA.

SURVIVEX 04 was the second SURVIVEX in the forward compartment of a 688 Class Submarine conducted under realistic DISSUB conditions with the first one being conducted onboard USS DALLAS in March 2003. SURVIVEX 04 had the following objectives: validate Commander, Naval Submarine Force (COMNAVSUBFOR) INST 3500.1 Submarine Readiness Manual Survivability Requirements, conduct exercise to refine atmospheric controls (i.e. heat generation, humidity, CO2 controls, pressure, Oxygen) and its effect on survivability, validate Change A to 688 Class Guard Book, and validate adequacy of 688 Class LIOH canister and Battelle curtain ship alterations.

Lessons learned will be incorporated in the next revision to the Guard book.

**Work Unit # 50508**

**Title:** Recommendations for DISSUB Escape > than 600FSW

**Principal Investigator:** W.G. Horn, MD

**Accomplishments (FY05):**

The Submarine Medicine and Survival Systems team have dedicated considerable effort in developing survival and escape procedures. NSMRL is an integral member of COMNAVSUBFOR Submarine Escape and Rescue Review Group, and is responsible on an ongoing basis for revisions to the Disabled Submarine Survival Guide, the Guard Book.

The team is also exploring the possibility of escape from depths greater than 600 feet. Finding survivors who do escape can be difficult, and NSMRL is testing new infrared reflecting streamers to enhance detection of DISSUB survivors at sea.

**Work Unit # 50522**

**Title:** NAVSCREEN Beta Test

**Principal Investigator:** J. Whanger

**Accomplishments (FY05):**

NSMRL's expertise and experience in the realm of psychological screening was recently leveraged at the Naval Service Training Center, as part of the Navy's efforts to maximize its return on human capital. An initial test of NAVSCREEN, based closely on SUBSCREEN but generalized for use with incoming sailors, was administered to a group of recruits at the Recruit Training Command. The Naval Education and Training Command will closely examine the results of this test for possible full implementation as a screening aid.

**Diving & Environmental Simulation Department**  
**E. A. Cudahy, Ph.D., Department Head**

**Work Unit # 50301**

**Title:** Testing and Evaluation of a Low Cost Retractable Needle Safety Syringe for Naval Health Care

**Principal Investigator:** J. Gertner, LT, USN

**Accomplishments (FY05):**

As of October 2005, testing has been completed in the clinical setting and with hot/cold syringes in the hyperbaric and ambient pressure environments. In order to complete the testing in extreme environments, we must complete testing in the hypobaric environment. This testing will take place in FY06. Safety Medical International (SMI), a medical manufacturing and technology development company is also preparing to deliver more syringes in a 3cc and 10cc size for testing as well.

**Work Unit #50308**

**Title:** Non-Lethal Bioeffects of Underwater Sound

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

IRB Protocols were written and approved as NSMRL 2004.0003, NSMRL 2004.0008 and NSMRL 2004.0010.

This study took measurement of vibration thresholds between 10 and 100 Hz. The study also took measurement of tolerance thresholds between 10 and 100 Hz and between 2,500 and 8,000 Hz. Animal model development and testing were completed during this time period. Data is being analyzed and a technical report is being written, NSMRL TR#1243.

(This research contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons without a "need to know", as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies public disclosure is governed by 5 U.S.C. 552 and 49 DFR parts 15 and 1520.)

**Work Unit #50401**

**Title:** Human Effects Evaluation of Non-Lethal Weapons

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

The measurement of a sound field generated by an air-gun source in a harbor environment was tested. This study also measured aversion of Navy divers as a function of distance from the source in a harbor environment. For more information refer to Cudahy, E.A., Schwaller, D.W., Fothergill, D.M., Trapani, C.L. (2004). Quicklook Report: United States Coast Guard Impulse Systems Tests – Airgun. NSMRL Memorandum Report #MR05-03. Groton, CT, Naval Submarine Medical Research Laboratory. Distribution authorized to U.S. Govt. Agencies Only.

Results will also be published in technical report NSMRL TR#1243.

(This research contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons without a "need to know", as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies public disclosure is governed by 5 U.S.C. 552 and 49 DFR parts 15 and 1520.)

**Work Unit #50409**

**Title:** Conduct Diver Test of Water Gun and Noise

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

The measurement of a sound field generated by a water-gun source in a lake environment was tested. This study also measured aversion of Navy divers as a function of distance from the source in a lake environment. For more information refer to Cudahy, E.A., Schwaller, D.W., Fothergill, D.M., Trapani, C.L. (2004). Quicklook Report: Naval Facilities Engineering Sciences Center and Johns Hopkins University Applied Physics Laboratory Impulse Systems Test – Watergun. NSMRL Memorandum Report #MR05-04. Groton, CT, Naval Submarine Medical Research Laboratory. Distribution authorized to U.S. Govt. Agencies Only.

Results will also be published in technical report NSMRL TR#1243.

(This research contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons without a "need to know", as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies public disclosure is governed by 5 U.S.C. 552 and 49 DFR parts 15 and 1520.)

**Work Unit #50410**

**Title:** Develop Ear Seal for Head-Mounted Hearing Protection with Improved Performance

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

NSMRL was tasked to develop a laboratory to test the acoustic attenuation properties of materials. The task has been delayed as the contractor failed to deliver the materials for testing.

**Work Unit #50503/5906**

**Title:** Effects of Low-Frequency Waterborne Sounds on Divers

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

The study measured threshold and aversion responses to low frequency (100 - 500 Hz) underwater sound in the open ocean. Other studies have been conducted in controlled quiet environments. The experiment was designed to validate previous research on the low frequency sound levels considered aversive. Obtaining this information in an open ocean setting validates the sound pressure level determined to be safe for military and recreational divers in a research program on the bioeffects of low frequency sound. This test was conducted in an open ocean environment while using an open circuit diving apparatus and a closed circuit diving apparatus.

Data collection for open circuit diving apparatus has been completed. Preliminary analysis indicates that divers can hear and feel the low frequency sound. Further findings will have to await completion of the analysis.

**Work Unit #50509**

**Title:** High Frequency Sound

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

The IRB Protocol NSMRL 2005.0004 was written and approved.

This study developed guidance for underwater sound exposure in the frequency range from 8,000 to 20,000 Hz and provided basic psychoacoustic information essential for the

development of underwater sound guidance. Future studies will also provide key information for assessing the effectiveness of neoprene hoods and other technologies for protecting the diver from sonar transmissions and other forms of high-level underwater sound. Final product will be a revised Appendix 1A of the US Navy Diving Manual.

**Work Unit #50510**

**Title:** Evaluation of Surfactant in the Prophylaxis and Treatment of Eustachian Tube Dysfunction and Middle Ear Squeezes in Divers Performing Repetitive Dives or Diving on 100% Oxygen

**Principal Investigator:** J. Gertner, LT, USN

**Accomplishments** (FY05):

A surface study was added due to a low number of subjects recruited for the hyperbaric portion of the study. The study also included the use of OAE tests before and after the dives and surface testing to check for any emission shifts. Data for six subjects were obtained for the surface study, and eight for the hyperbaric study. Data collection is complete and a report is being prepared.

**Work Unit #50511**

**Title:** Underwater Loudhailer

**Principal Investigator:** E. A. Cudahy, Ph.D.

**Accomplishments** (FY05):

To give port security forces more time to respond to potential threats, an underwater loudhailer system with significant range is needed. Current underwater loudhailers operate over an extremely limited range. The objective of this study was to quantify and evaluate the intelligibility of speech transmitted to divers over a prototype underwater loudhailer (eLOUDTM). Testing was performed in Narragansett Bay in Rhode Island in June 2005. Findings of the study indicate that the prototype is capable of transmitting a closed set of verbal warning-phrases to a range of 400 yards with > 90% intelligibility, with no diver discomfort reported at 50 yards. Trends in the speech intelligibility data, measured received levels, and articulation index predictions suggest that adequate intelligibility of well-known phrases is possible to 500 yards. The eLOUDTM prototype appears to be a reliable system for projecting intelligible American-English warning messages to significant ranges. We recommend distributing recordings of standard Coast Guard warning tones and messages among diving instructors, so they can familiarize their students to the Coast Guard's underwater audio warnings. A Technical Report was approved on 14 December 2005, and designated as NSMRL Technical Report TR#1244, "Speech Intelligibility Evaluation of an Underwater Loudhailer Prototype."

**Work Unit #50512**

**Title:** Lung Resonance of Immersed Divers

**Principal Investigator:** D. Fothergill, Ph.D.

**Accomplishments** (FY05):

The objective of the study will be to determine the fundamental resonance frequency of the human lung during warm water immersion as a function of diver orientation and diver depth from surface to 5 ATA. The data obtained will be compared with calculations from mathematical models of lung resonance to determine which model best fits the empirical findings. The IRB protocol has been written and approved, and the Oscillometry equipment has been built. Surface testing of the frequency response of the Oscillometry equipment has been accomplished. Software for computerized generation of sound presentation via the Oscillometry equipment has been developed. The first human test is planned for end of FY05.

**Work Unit #50514**

**Title:** Location and triage of disabled submarine survivors

**Principal Investigator:** J. Gertner, LT, USN

**Accomplishments** (FY05)

In the event of a rescue on a disabled submarine (DISSUB), first responders will be faced with triage of survivors in the dark, cramped, possibly partially flooded submarine with a questionable atmosphere along with varying degrees of hypothermia or hyperthermia. This is a difficult process and there is currently precious little equipment developed for assisting in this effort. This project was designed to test various pieces of triage equipment to evaluate for use onboard submarines during a DISSUB rescue.

The objectives of the study include providing guidance on triage equipment identified as appropriate for use onboard the rescue vehicle when responding to DISSUB scenario and evaluation of equipment for future use as well as any possible modifications to the DISSUB guidelines for triage and extraction.

Several different products were tested onsite at the lab and at the Escape trainer on submarine base New London. Instruments were tested on their function versus the current solution- for instance infrared imagers to search for survivors were compared against using a flashlight in a compartment. Likewise, life detection instruments were compared against a palpable pulse. All instruments were evaluated based upon factors such as speed, cost, dependency, ease of use, and size and compared against current solutions.

Currently, the data collection is complete and analysis and generation of a written technical report is all that remains to be accomplished.

**Work Unit #50516**

**Title:** Surfactant Project

**Principal Investigator:** J. Gertner, LT, USN

### **Accomplishments** (FY05)

This research will provide the military, operational and medical community a safe and inexpensive medication, to both prevent and treat pulmonary oxygen toxicity.

Excellent progress has been made on the inhaled surfactant medication. The plan is to have the FDA Investigational New Drug (IND) application complete in the upcoming months. Progress has been made on the delivery vehicle. A handheld delivery vehicle may be used, this is similar to a metered dose inhaler, and is a vast improvement over the original design.

Discussions have begun with Discovery Labs who continue research on a Metered-Dose Inhaler (MDI) version of surfactant. Trials with various surfactants may be important as some formulations come with or without surfactant proteins and may have a great influence on efficacy.

**Human Performance Department**  
**LCDR L.J. Crepeau, MSC, USN, Department Head**

**Work Unit #50408**

**Title:** Signal Processing Requirements for Spatial-Vernier (SV) Audio-Beamforming on Wide Aperture Array (WAA) for enhanced collision avoidance

**Principal Investigator:** J. Russotti, M.S.

**Accomplishments** (FY05):

The signal processing task carried out in this research over the past 12 months was to determine if differences between beams could be demonstrated using the onboard Wide Aperture Array (WAA) that were directly attributable to the target signal and if these differences would yield information as to where the target is located. Earlier analysis on a simpler linear hydrophone array shows that the characteristics of focused, or spatial vernier beamforming could be harnessed to produce the conditions needed to produce the effect. The first array that this technique was applied to was the current TB-29 towed linear array. The signal processing that was investigated formed a set of beams at a series of increasing ranges while looking in the same direction for all beams. By keeping "look direction" constant for all beams, a very high noise correlation can be achieved between beams. The results of the study proved conclusively that total target energy show a marked increase as the target came into focus, i.e., the time delay used in beamforming corresponded to a distance equal to that of the target. Audio data of the beamformed energy were produced for use in human testing. The results of human testing were very positive and showed the potential for application in more operationally useful but more complex array.

The technique was then applied to the Wide Aperture Array (WAA). Again the evaluation conditions were the same as for the TB-29 line array.

- All noise was generated at infinity, i.e., modeled as plane waves.
  - Two noise generators were produced: a sinusoidal wave and random component wave. The resulting noise signal is the vector sum of these two components.
  - The noise correlation between beams can be simulated by varying the relative strengths of the sinusoidal component and the random component of the noise signal.
  - Noise was distributed uniformly over all look directions.
- The target signal was modeled as point source located at a finite distance and direction emitting spherical waves.
  - Preliminary simulations have the target signal location as broadside to the line array.
- Net signal samples from each receiver were taken at time intervals consistent with focused beamforming. The resulting samples from all of the receivers are then integrated to form a net signal.
- Net signals for each beam were Fourier analyzed. The Fourier components between adjacent beams (in range) were subtracted and the resulting difference signal was re-generated.

Analysis of the difference signals of the simulation runs at varying target distances using the WAA show a peaking of the difference signal as the beam focuses on the target. This promising result appears very similar to findings in our earlier analysis of the TB-29 linear array. Initial analysis used a single panel of the WAA, further analysis showed that using three panels of the array yielded results even stronger than those found for the TB-29 linear array. Signal processing applied to the TB-29 array based upon those findings using actual sonar contacts yielded detections that indicated greater than double the distance in detectability. Signal processing is now being similarly applied to the WAA using actual sonar contacts. NSMRL sonar test software was redesigned to refine the detection measurement testing procedure. Target and background wave files are being beamform processed at NUWC. Processing is near completion.

**Work Unit #50506**

**Title:** Hearing Loss Simulator for Hearing-Conservation Application

**Principal Investigator:** L. Marshall, Ph.D.

**Accomplishments** (FY05):

Objective of the study is to conduct research to assess the effectiveness, design appropriate training protocols, and demonstrate the technology for a hearing loss simulator to be used in individualized hearing-conservation training of military personnel.

- Re-design of the Sensimetrics simulator interface for our device has begun. Other work on the project has focused on testing and debugging the interface, debugging the digital-signal processing (DSP), and making improvements to the headset assembly.
- Military audiologists have provided input on how they would use the simulator and what features they would like to see in it.
- The approach to the selection of Army and Navy NIHLs for defaults in the simulator has been expanded. A large Navy database from NEHC has arrived.
- The data on which to base the alteration in effective signal-to-noise ratio for speech (which will also be applied to environmental sounds) associated with NIHL have been selected.
- A long list of potential environmental sounds was generated and interviews are taking place with people (e.g., auto mechanic, high-school woodworking teacher) having expertise in various sub-areas about perceived high-frequency content and potential importance of each of the sounds.
- Dr. Marshall recruited a set of audiologists who personally have tinnitus and/or a caseload of tinnitus patients as a willing resource.

*Input from Navy and Army Audiologists*

Military audiologists provided feedback on applications for the simulator, and many indicated eagerness to help with the project in the following ways – collecting any data needed for simulator design, attending a meeting in FY06 to finalize the simulator design, and evaluating a prototype of the simulator in FY07. They had many very good suggestions. One was to describe the hearing loss not by “dB of loss,” but rather by “associated age” (e.g., “you will have the hearing of a 50-year-old man”). Another was to simulate both a conductive component

(which models hearing protection) and a sensorineural component (which models NIHL) to the hearing loss. This has already been implemented (see above). The table below shows the composition of the military audiologists who commented on the simulator.

Table 1. Participating Audiologists

	Navy	Army	Air Force
Military	6	4	1
Civilian	6	3	0

#### *Selection of Army and Navy NIHLs*

The simulation will be of those who have the most hearing loss in the Army and Navy as a function of age. The Army's will come from clinical records at Walter Reed Army Medical Center (WRAMC) and will be the average H-3 profile (an Army definition of poor hearing) for each age grouping. The Navy will select a low percentile of hearing thresholds from a large NEHC database. Originally we were going to look only at Army hearing losses. However, we decided that it is important to include both Army and Navy audiograms because the types of noise exposure are different for the two populations.

#### *Environmental Sounds*

Lists of environmental sounds are being evaluated for perceived high-frequency content and relevance/importance to each category by experts in each of the sub-areas of sounds: machinery, tools, vehicles, other metal sounds, wind, water, household, bells and alarms, electronics, sports and recreation, feet, guns, humans, birds, frogs, insects, snakes, pets, farm animals, rodents, general outdoor locations, music. In addition, a list of potential environmental sounds specific to military applications is being compiled.

#### *Tinnitus*

Publications and recordings relevant to the tinnitus simulation have been identified. Potential subject populations (should we decide that we need data on the perceived interference from tinnitus, which is available in the scientific literature) have been identified as audiologists in the state of Connecticut who themselves have tinnitus and audiologists who see many tinnitus patients and would be willing to recruit subjects for our work (achieved at a Tinnitus Workshop attended by Dr. Marshall).

#### **Work Unit #50513**

**Title:** Evaluating a fixed 8-hour submarine watchstanding schedule

**Principal Investigator:** L. J. Crepeau, LCDR, USN

#### **Accomplishments** (FY05):

An underway study was conducted aboard the USS MARYLAND (SSBN 738) 7 May - 3 June 2005. During that time, submariners followed the FIXED 8 schedule for two weeks, then followed the standard 6/12 submariner schedule for 11 days. Two subjects served for the polysomnographic sleep portion of the study, and six sleep records were collected from each subject in each condition. These have been completely analyzed. Saliva samples were collected

every 2-3 hours from 24 subjects during the entire 25 days. Samples were rapidly frozen and stored in the submarine's freezer until reaching port, then sent to the Naval Institute of Dental and Biomedical Research, Great Lakes, IL.

Subjects also completed PDA-administered cognitive tests and, at the end of the study, completed questionnaire surveys to provide their subjective opinion of the FIXED 8 schedule. This questionnaire was also administered to non-subjects. In all, more than 100 Submariners completed the questionnaire, and we collected more than 5,000 saliva samples from 24 subjects, and 2000 sleepiness ratings, reaction time, and working memory performance data points from 36 subjects. These are currently being analyzed.

We have also begun analyzing more than 15,000 hours of actigraph-derived data, and obtained specialized software that characterizes sleep episodes using the actigraph data. These analyses will determine the restorative quality of sleep obtained by crewmembers while following the traditional and an alternative watchstanding schedules, a crucial step toward distinguishing the advantage of the alternative schedule. We also summarized the results of the questionnaires used to glean Submariners' sentiments regarding the two schedules.

**Work Unit #50517**

**Title:** Otoacoustic Emissions and the Auditory Efferent Reflex

**Principal Investigator:** L. Marshall, Ph.D.

**Accomplishments (FY05):**

*TEOAE Reliability: Spectrum vs. Peak Calibration*

One approach to decreasing variability in TEOAE measurements, which we developed in an earlier grant, is to use an adaptive calibration procedure, called "spectrum calibration" to modify the spectrum of the in-the-ear stimulus to match the desired stimulus. This is in contrast to the more common "peak calibration." Previously we had shown that this procedure markedly improved the stimulus spectrum across ears. Recently we analyzed the existing data of a small group of subjects where multiple measurements had been made with spectrum calibration and with peak calibration to see if spectrum calibration increased the test-retest reliability of the TEOAE measurement. Three series of identical measurements were made in 14 ears. The measurements were made first using the original peak calibration procedure, then with the spectrum calibration procedure, without changing the position of the probe. Between each series or "repeats," the probe was repositioned in the ear canal, and then the series of measurements was repeated. In repeat 2, the probe was replaced with the aim of getting the same probe fit as in repeat 1. In repeat 3, the probe was fitted so that the probe fit was different. The aim was to see to what extent spectrum calibration could compensate for a bad/different probe fit – a realistic situation where previous records are not available or with inexperienced testers. We hypothesized that test-retest reliability would be better for repeat 1 and repeat 2 (similar probe fit) versus repeat 1 and repeat 3 (different probe fit) and that spectrum calibration (our new method) would be more reliable than peak calibration (old method available on clinical equipment).

A useful measure of test-retest variability is the standard error of measurement (SE<sub>meas</sub>), which is related to one component of the ICC. The smaller the variability, the smaller the difference that can be reliably detected, as can be seen in Figure 1, test-retest variability was noticeably smaller for spectrum calibration at frequencies below 2.8 kHz, both for repeat 2 and repeat 3. Frequencies below 2.8 kHz are the ones of interest for measuring the efferent reflex. Reliability decreased for both spectrum and peak calibration for repeat 3, but the decrease was substantially worse for peak calibration. It appears that spectrum calibration can help improve reliability, but it is not the only factor. Taking the time to get a good probe fit is still important.

These estimates are illustrative only; there are not enough ears included to generate criteria for use in a population. However, the overall trend is for spectrum calibration to achieve better test-retest reliability than peak calibration. For AER measurements, we will use the new spectrum calibration.

An unexpected result was that there were more usable TEOAE data when using spectrum calibration, compared with peak calibration. Many measurements did not achieve good signal-to-noise ratio when peak calibration was used. Obtaining more usable data further justifies the use of spectrum calibration over peak calibration.

#### *TEOAE Reliability: Various Stimuli Measured on the Mimosa Acoustics System, With Comparisons to the Old Otodynamics ILO System*

We then calculated the reliability of four different TEOAE stimuli: clicks, Dau chirps, and Shera chirps, all with the same bandwidth, and a narrower-band click thought to be more promising as an AER stimulus. All were presented at 47 dB SPL(rms). The method was similar to above, with one repeated measurement series, with the probe refitted between the two series of measurements. From 35 to 57 ears contributed to each estimate, so these reliability estimates may be used as criteria for significant TEOAE changes in individual ears when measured using identical protocols.

#### *Systems Modifications Specified*

Modifications to the Mimosa Acoustics were specified. These included (a) completing the porting of the SFOAE and TEOAE systems to a new signal-processing board, (b) automatic estimation of spontaneous-otoacoustic-emissions frequencies, (c) power-law spacing of SFOAE frequencies (as recommended by Dr. Shera), and (d) automatic retesting of SFOAE frequencies with bad stimulus levels, high noise floors, or low signal-to-noise ratios.

Unusual for our laboratory, we were invited to contribute a chapter to the prestigious third edition of "Otoacoustic Emissions: Clinical Applications," edited by M.S. Robinette and T.J. Glatke. Previous editions of this book are a standard reference in the field, and are widely read by clinicians, researchers, and university educators. We accepted the offer, and recently submitted our entry to the editors, who received it with much enthusiasm. The chapter was entitled "Otoacoustic emissions as a preclinical measure of NIHL and susceptibility to NIHL," and encompassed an extensive literature review, including a discussion of the use of the auditory efferent reflex as a potential predictor of susceptibility to NIHL.

COMMAND HISTORY  
Fiscal Year 2005  
Part 2

2. Special Topics as applicable

(1) Statistics on major functions:

LCDR Thomas Herzig, Executive Officer, traveled to Bethesda, MD from 19-20 October 2004 to work with the finance committee of the American Physiological Society. In addition to reviewing the current operating budget and setting the 2005 budget for this national professional society, LCDR Herzig and the committee reviewed the operating revenues and expenses for the International Congress of Physiological Sciences being held in San Diego from 31 March-5 April 2005.

CAPT Christopher Daniel, Commanding Officer, LCDR Thomas Herzig, and Dr. Jerry Lamb, Technical Director visited Naval Experimental Diving Unit (NEDU), Panama City, FL, on 5 November 2004 to discuss collaborative research opportunities between our laboratories. Briefs from NEDU and NSMRL were shared to determine the best potential for collaboration and synergy between the research facilities. In addition, discussions began on how best to maintain NAVSEA-directed diving requirements during the upcoming maintenance of the Ocean Simulation Facility at NEDU.

Major General Termidzi, Surgeon General for Malaysia, visited NSMRL in October 2004. He attended the Change of Command, was given a tour of our facilities, and discussed potential research collaborations.

Dr. Greg Wakefield, University of Michigan Co-Investigator on the Auditory Technology and Management in Modern Navy Systems project, delivered MATLAB scripts for generating new auditory stimuli to Dr. Tom Santoro at NSMRL. These complex sounds, called spectral profiles, are created from combinations of pure tones that have either a linear or a logarithmic frequency relationship and differ according to amplitude increments for certain tones. Wakefield and others have studied the ability of listeners to discriminate such sounds. The behavior is reasonably well understood and documented in the psychoacoustics literature. The stimuli will be used in a study of auditory-visual learning transfer in collaboration with Dr. Stephanie Doane of the University of Mississippi. Dr. Doane, in collaboration with Dr. Santoro, will determine if recognition skills learned for complex visual patterns such as polygons or aircraft silhouettes can transfer to recognition of auditory patterns. Initial transfer performance will be characterized using visual patterns and certain spectral profile sounds in diotic listening. Further testing will be done with tactical situation displays and spatialized transient sounds of increasing numbers typical of a dichotic passive sonar listening environment.

The French Navy recently discovered plans in their archives for the U.S. Navy's first submarine, the USS ALLIGATOR. The submarine was designed by a Frenchman, Brutus de Villeroi and was launched in 1862 in Philadelphia. Its first operational use ended in failure due to inability of the submarine to submerge in shallow waters. The submarine sank off Cape

Hatteras in 1863 while being towed to Charleston, SC. The National Oceanographic and Atmospheric Administration (NOAA) and ONR initiated a joint project to search for the ALLIGATOR. NSMRL was asked to examine the ALLIGATOR design and evaluate its atmospheric life support equipment to determine how long the crew could work in the submarine while submerged. NSMRL staff including CAPT Ray Woolrich (Ret.), Mr. David Burnside, SurgCDR Peter Benton, Dr. Sal DiNardi, CDR Tony Quatroche (Ret), and Dr. Horn found that the submarine was so small that the enclosed atmosphere volume limited submerged time to less than an hour. However, the atmosphere equipment could theoretically prolong submergence time for up to several hours or longer, based on limited design plans and information. The Discovery Channel visited NSMRL and the USS NAUTILUS Museum at Naval Submarine Base New London, filming a small-scale demonstration of the carbon dioxide scrubbing used on ALLIGATOR and new submarine atmosphere control equipment tested at the lab. Dr. Horn participated in the Nauticos Museum's annual Maritime Heritage Conference on the Search for the USS ALLIGATOR in Norfolk, VA, on 29 October 2004, delivering a brief to attendees including RADM Jay Cohen, Chief of Naval Research, on ALLIGATOR's atmosphere control capability.

NSMRL's Submarine Atmosphere and Health Assessment Program staff attended the quarterly Closed Living Space Environmental Concerns Working Group meeting in Norfolk, VA, on 9 November 2004. Items discussed included the impact of smoking in submarines, potential exposure to diesel exhaust, and toxic compound exposure limits. Attendees included CAPT Ray Woolrich (Ret.), Mr. David Burnside, SurgCDR Peter Benton, Dr. Sal DiNardi, and Dr. Wayne Horn.

The fast attack submarine USS SALT LAKE CITY took part in SURVIVEX 2004, from 9-12 December. While pier side in San Diego, CA, approximately 80 crewmembers along with Dr. Wayne Horn and SurgCDR Benton from NSMRL, and several medical personnel remained in the forward compartment of USS SALT LAKE CITY, simulating a disabled submarine. This exercise is part of the Submarine Force's escape and rescue program and evaluated the ability of a submarine crew to maintain a survivable atmosphere and adequate living conditions while waiting for rescue. This SURVIVEX exercise validated the procedures for using carbon dioxide (CO<sub>2</sub>) scrubbing technology to limit atmospheric CO<sub>2</sub> levels to survivable concentrations under realistic disabled submarine (DISSUB) conditions. A secondary purpose was to assess the utility of the senior survivor's guidance (GUARDBOOK) as an asset to the crew of a DISSUB in anticipating conditions on board the vessel under varying survival scenarios. An initial release of information was presented to NAVSEA, while additional details will be provided following the analysis of the extremely large data set.

LCDR Christopher Duplessis and Mr. Joe Russotti from NSMRL participated in the Limited Objective Experiments (LOEs) conducted on the HSV 2 (SWIFT), a surrogate vessel for future high-speed ship development on 14-16 December 2004. The field evaluation of the noise reduction (NR) stethoscope, developed at NSMRL for use in noisy environments, was an unequivocal success. A mobile shelter erected on the Mission Bay area of the HSV Swift designated for patient care consistently exhibited noise levels approaching 100 dB SPL. Abnormal cardiac and pulmonary sounds were generated by a patient simulation mannequin supplied for the exercise by the Naval Medical Education and Training Command. Approximately 20 health practitioners evaluated the NR stethoscope in this environment with

a consensus opinion regarding its superiority in allowing confident detection of abnormal pulmonary and cardiac sounds at this level of ambient noise.

Dr. Mark Bing and LCDR Thomas Herzig attended the Personnel Responsibility Program (PRP) in Crystal City, VA on 13 January 2005. NSMRL demonstrated how it uses SUBSCREEN and SMART (SubMarine Attrition Risk Test) in the psychological screening of prospective submariners as an adjunct to the PRP. The presentation and data were well received, leading to PRP administrators asking if SUBSCREEN and SMART, or a similar program, could be used by other agencies. In addition, PRP plans to send data to NSMRL to perform a prospective analysis on a database of submariners to determine if SUBSCREEN's SMART can predict PRP decertifications.

Neal W. Pollock, Ph.D., of the Center for Hyperbaric Medicine and Environmental Physiology at Duke University Medical Center in Durham, NC, visited NSMRL from 9-11 February to conduct an Ultrasound and Decompression Research Workshop for NSMRL staff in support of the protocol, "Statin therapy to decrease the risk of decompression sickness (DCS)." Dr. Pollock is a recognized expert in the field of diving research and, in particular, in exploitation of ultrasound methods to characterize bubble load post-hyperbaric exposure. Doppler ultrasound interrogation for bubble load is the accepted gold standard to assess decompression obligation and decompression risk. This training encompassed 12 hours of didactics in ultrasound and Doppler therapy, and 20 hours of practical experience. This training was an overwhelming success, making the lab more effective at competently employing these techniques in decompression studies.

LCDR Thomas Herzig attended the Gordon Research Conference on Chemical & Biological Terrorism Defense from 30 January–4 February. Attendees were from numerous governmental agencies and laboratories, providing insights from the local, state, and federal level. In addition, participation from universities, corporations, and international interests fostered lively discussions. The conference covered a broad range of topics from Homeland Security issues to Public Health Surveillance and mass response. Chaired by a senior leader of the Department of Homeland Security, the topics included Threat Assessment and Awareness, Prevention, Protection, Surveillance and Detection, Response and Recovery, as well as Response to Future Threats.

Dr. Edward Cudahy and Dr. Jerry Lamb attended the Joint Forces Command (JFCOM) Force Protection Review on 1-2 February in Norfolk, VA, where Dr. Cudahy presented a paper on Diver Deterrence. The meeting was held to review the status of current Force Protection (FP) initiatives and planning for implementation of improved FP measures.

Researchers from NSMRL met with department heads and key personnel from COMSUBDEVRON 12 in an Information Exchange on 17 February. The meeting followed on the heels of a recent visit and brief at NSMRL by CAPT Frank Caldwell, the Commodore of COMSUBDEVRON 12; the purpose of this session was to elucidate the multiple areas where NSMRL's scientific resources overlap with the current key human performance and situation awareness concerns of COMSUBDEVRON 12. The meeting resulted in some frank and spirited discussion, paving the way for continued collaborative efforts and further contributions by NSMRL to COMSUBDEVRON 12's tactical development mission.

CAPT J. Christopher Daniel and Dr. Wayne Horn attended the Submarine Escape and Rescue Review Group (SERRG) Biannual Conference in Washington, DC, where Dr. Horn presented the results of the recently completed SURVIVEX 2004 exercise and updated the group on the many other areas in which NSMRL is tasked. NSMRL is an integral part of this important working group, which is chaired by Commander, Submarine Development Squadron 5. In addition to making recommendations to CNO N77, NAVSEA, and COMNAVSUBFOR for setting requirements for increasing survivability following submarine mishaps, the SERRG is the vehicle by which many of the products, techniques and processes developed and tested by NSMRL transition to the submarine fleet.

Dr. Jerry Lamb co-chaired the Unmanned Water Vehicles Conference in Falls Church, VA on 8-9 March. The conference addressed key issues including emphasizing the capabilities of future Unmanned Water Vehicles, capitalizing on initiatives and advancements in ongoing technology, maximizing developments in structural design and weapons platform configurations, enabling industry to promulgate and enhance developments in Unmanned Water Vehicles, and focusing on Naval capabilities to determine future strategies in warfare and maritime security.

The Submarine Atmosphere Health Assessment Program (SAHAP) hosted a meeting at NSMRL on 9 March to discuss the preliminary results from last month's first-ever 688 Class SSN atmosphere sea trials. Attendees included Mr. R. Hagar, NAVSEA; Mr. T. Daley, NSWC Philadelphia; Dr. S. Rose-Pehrsson and Dr. K. Johnson of NRL. NSMRL attendees included Mr. David Burnside, SurgCDR Peter Benton, CAPT Ray Woolrich (Ret), and Dr. Sal DiNardi. The group reviewed the reports from the various laboratories that analyzed the samples, comparing the results to the Navy's 90-day limits for submarine exposure. Action items were assigned with the objective of completing a technical report delineating the data analysis.

LCDR Loring Crepeau was an invited moderator during the 24th American Association of Underwater Scientists (AAUS) Annual Diving for Science symposium, held 10-12 March in Mystic, CT. The AAUS represents scientists involved in diverse areas of underwater research. LCDR Crepeau briefed the group on some of the current diving projects underway at NSMRL and was invited to provide a comprehensive presentation at their next annual meeting.

Six NSMRL staff visited the Royal Navy Submarine Escape Training Tank (SETT) in Portsmouth, UK, to verify performance of a new search and rescue signaling device and attend submarine escape training. Dr. Wayne Horn and Ms. Sandra Wagner verified performance of the device during and after an escape from a depth of 100 feet in the RN training tower facility. Four NSMRL divers, Mr. Frederick Donlon, BMC(DV) Brian Kerr, HTFN(DV) Richard DiSanto, and IT3(DV) Nicholas Atkinson successfully performed two escapes each using the new Mark 10 submarine escape suit. NSMRL will assist in the U.S. Navy's first at-sea submarine escape exercise in over 40 years later this year.

CAPT J. Christopher Daniel, LCDR Thomas Herzig, and Dr. Jerry Lamb attended the 2005 Joint Undersea Warfare Technology Spring Conference, "Altering the Calculus: Integrated Undersea Warfare" National Defense Industrial Association, in San Diego, CA, from 28-31 March 2005. Dr. Lamb presented "Situational Superiority, Tactical Competence Beyond

Situational Awareness,” authored by LT Katharine Shobe, Human Performance Detachment Submarine Learning Center, Mr. Richard Severinghaus, and Dr. Jerry Lamb.

NSMRL hosted the Ninth Annual Fleet Review on 28 April 2005 to solicit feedback, guidance, and recommendations on the laboratory’s research efforts in support of the undersea operational forces. Principal Investigators gave briefs on Information Processing & Display, Human Systems, Atmospheric Monitoring, Psychological Assessment, Medical & Physiological Readiness, Submarine Survival & Escape, and Underwater Bioeffects & Force Protection. The Review panel included RDML Kenny, Commander, COMSUBGRU 2; CAPT McCarthy, Director Medical R&D, BUMED; CAPT John Murray, NAVSEA 00CM Deep Submergence; CAPT Richardson, Commodore, DEVRON 12; and CAPT Hinman, SUBFOR Medical Officer.

Dr. Lynne Marshall was presented with the Military Audiology Association Research Award 2004, for her outstanding contributions to military Audiology Research.

On 25-26 April 2005, Dr. Horn presented the SURVIVEX brief to Commander Lunney and the waterfront boat and squadron representatives and leadership. Rear Admiral Cassias, his staff, and several of the commodores and squadron staff members in Pearl Harbor were also briefed. On 2 May Dr. Horn briefed Vice Admiral Munns and his staff members on SURVIVEX, and then traveled to Norfolk, VA, to brief Admiral Donald at Naval Reactors on the same.

Dr. Cudahy was an invited speaker at the Gulf Coast Military Exposition and Symposium, “How Do We Make Homeland Defense and Homeland Security Seamless?” on 10-11 May 2005 in New Orleans. Dr. Cudahy was part of the Panel Discussion on how to use technology to bridge the gap.

LCDR Thomas Herzig supported the Office of Naval Research (ONR) as a Special Awards Judge at the International Science and Engineering Fair from 10-12 May, in Phoenix, AZ. Competition was keen among all the categories, but especially among the 127 projects in Medicine and Health sciences. ONR awarded Sarah Mousa, a Junior at Columbia High School, East Greenbush, NY, the top prize in Medicine and Health for her work entitled, “Implications of Nicotine’s Pro-Angiogenesis Activities: The Good and The Bad.”

CAPT J. Christopher Daniel, Dr. Jerry Lamb, and Mr. Rick Severinghaus briefed RDML Van Buskirk, Director of the CNO’s Total Force Task Force on 31 May, and VADM Moran, Chief of Naval Education and Training on 3 June, regarding the SUBSCREEN program. Both briefs were well-received and prompted further interest in NSMRL’s ongoing work in predicting attrition using portions of the SUBSCREEN, and in interventions to reduce such attrition. Points of contact were provided for NSMRL to provide additional information on SUBSCREEN for submarine force personnel, while planning has begun for a possible pilot program for administration of the SUBSCREEN test to all new recruits at the Naval Service Training Center in Great Lakes.

The Closed Living Space Environmental Concerns Working Group (CLSECWG) meeting was held 12 May at NSMRL. As a result of this meeting, the CLSECWG has recommended new CO<sub>2</sub> limits for the submarine atmosphere control manual. In addition, the CLSECWG has

recommended that work be undertaken to better define the risks of second-hand smoke on submarines.

From 8-10 June in Arlington, VA, Principal Investigators from NSMRL participated in the NAVSEA/ONR/BUMED/SPECWAR Undersea Medicine Research Program Progress Review. Dr. David Fothergill gave an update on the progress of undersea medicine research efforts on Mechanisms to Improve Nitrogen Elimination and Reduce the Incidence of Altitude Decompression Sickness; Dr. Edward Cudahy presented on Underwater and Dive Station Work-Site Noise Surveys, Underwater Sound Localization, Diver Noise Exposure Limits and Protective Gear, High Frequency Sound, and Effects of Carbon Dioxide and Oxygen Levels on Auditory Sensitivity and Frequency Tuning. LCDR Christopher Duplessis presented his research in Surfactant for the Treatment and Prevention of Pulmonary Oxygen Toxicity, Sea Trials of New Submarine Watchstanding Schedule, and Submariner Bone Turnover and Vitamin D Supplementation. Finally, Mr. Joseph Russotti presented his research on Binaural Displays for Collision Avoidance in Close – In Undersea Environments.

VADM Donald C. Arthur, Navy Surgeon General, presented CAPT J. Christopher Daniel with NSMRL's first Meritorious Unit Commendation (MUC) in its 59-year history during an award ceremony on 5 July. NSMRL's staff earned the award for service from 1 Jan 1994 through 31 Dec 2002. During this timeframe the staff consistently demonstrated expert scientific and technical knowledge in biomedical research, development, test and evaluation of submarine, diving, and medical systems and procedures to support the ever-changing operational requirements of the U.S. Armed Forces, according to the award citation.

LCDR Loring Crepeau and LCDR Christopher Duplessis traveled to the Naval Institute of Dental and Biomedical Research in Chicago, IL, from 30 June to 8 July. They conducted Enzyme-Linked Immunosorbent Assays on more than 2,400 saliva samples to determine cortisol and melatonin levels. The saliva samples were collected while underway aboard the USS MARYLAND (SSBN 738) during a month-long study that compared the standard 6 hour on, 12 hour off submariner watchstanding schedule to a fixed 8 hour on, 16 hour off (FIXED 8) schedule. The cortisol and melatonin levels, when subjected to a cosinor analysis, will reveal whether the submariners' circadian rhythms entrained to their respective work shift while following the FIXED 8 schedule.

CAPT J. Christopher Daniel traveled to Washington, D.C. from 11-12 July to serve as a keynote speaker on medical aspects of Expeditionary Warfare at the Joint Expeditionary Warfare Symposium.

CAPT J. Christopher Daniel, Dr. Jerry Lamb, Ms. Alison America and Mr. Rick Severinghaus visited the Naval Training Service Command (NTSC) in Great Lakes, IL from 13-14 July, to plan implementation of a beta test of SUBSCREEN for recruits at Recruit Training Command (RTC), at the request of VADM Moran, Commander, Naval Education and Training Command. The NSMRL team observed RTC in-processing and training, and attended coordination meetings with staff from RTC and NTSC, Human Performance Center detachments at both Great Lakes and Groton, Navy Personnel Research, Studies, and Technology from Millington, TN, and the Recruit Evaluation Unit and Mental Health Department of Naval Hospital Great Lakes, IL. Prior to returning to NSMRL, the team briefed the Chief of Staff of NTSC and the

Commanding Officer of RTC on the plans for conducting a pilot test in September, followed by the beta test which will be conducted in FY06.

Dr. Michael Qin was an invited speaker and won second place in the “Oral Presentations” category in this year’s Conference on Implantable Auditory Prostheses (CIAP) 2005 Young Investigator Awards competition 30 July – 4 August in Pacific Grove, CA. Presentations were judged on the originality of the work, methodological rigor, interpretation of the results, and clarity of the presentation.

Dr. Jerry Lamb, Mr. Jim Whanger, and Ms. Alison America traveled to Great Lakes, IL on 22-24 August and 16-17 September to prepare for and conduct the NAVSCREEN pilot test. This study is intended to assess whether a revised version of the SUBSCREEN test can predict negative behaviors and attrition for negative cause among all Navy recruits. The pilot test was successful as we learned that a few items needed to be revised for clarity and that testing time is similar to our experience with BESS students at NAVSUBSCOL. Analysis of the preliminary data is ongoing. The beta test will begin 15 October and continue until both predictor and criterion data has been collected from 3000 recruits.

LCDR Loring Crepeau attended the Preventing Sleep Deprivation Principal Investigator meeting in Charlottesville, VA on 22-24 August. He kicked off the meeting as the invited speaker, presenting preliminary findings from the watchstanding study conducted aboard USS MARYLAND (SSBN 738) while underway on patrol May-June 2005. The study’s intent is to determine whether a 24 hour-based, fixed 8-hour (FIXED 8) watchstanding schedule enhances the alertness, vigilance, and performance of watchstanders. The data presented were limited to submariners’ subjective appraisal of the FIXED 8 schedule. Compared to the current 6 hour on, 12 hour off submariner watchstanding schedule, submariners more positively rated the FIXED 8 for providing longer sleep, enhancing energy levels, elevating crew morale, increasing satisfaction with watch schedules, and improving concentration. Subsequent analyses will characterize wrist-worn actigraph, PDA-administered performance, and salivary cortisol- and melatonin-derived circadian entrainment data.

Dr. Wayne Horn and SurgCDR Paul Turnbull attended the Asia Pacific Submarine Conference in Pearl Harbor, HI from 12-16 September. Virtually all Pacific and several Indian Ocean nations were represented at the APSC, including both Russia and China. The conference was themed around cooperation in Submarine Escape and Rescue. Russia, the UK, and Deep Submergence Unit San Diego had excellent presentations on their respective roles in the RFN submersible AS-28 incident off Petropavlovsk. Lessons learned included the importance of understanding the capabilities of the receiving airfield when deploying rescue assets and the need for technically competent translators. All three activities experienced major problems with communications and lack of interpreters. Members of the Russian Navy delegation were frank and open. Dr. Horn presented findings from SURVIVEX 2004. There were also briefings on Exercise Sorbet Royal 2005 (the major NATO submarine escape and rescue exercise held off Tarranto in June) and on the progress in the US SRDRS and the UK/FRA/NO NSRS submarine rescue systems, both of which should enter service in 2007.

The NDIA and NUWC Joint 2005 Undersea Warfare Technology Conference was held on 13-15 September at SUBASE NLON. CAPT J. Christopher Daniel, LCDR Thomas Herzig, Dr. Jerry

Lamb, Dr. Michael Qin, Mr. Joseph Russotti, and Mr. Ronald Joe attended several of the briefings. Dr. Lamb presented, "Situational Superiority: Tactical Competence beyond Situational Awareness."

(2) Average number of military and civilian personnel onboard in FY05.

Military Officer	5
Military Enlisted	9
Civilian Professional	7
Civilian Supporting	<u>7</u>
Subtotal	28

Contractors	
GeoCenters	9
IPAs	<u>4</u>
	13
TOTAL	41

(3) Major command problems faced during this year. None

## COMMAND HISTORY

Fiscal Year 2005

### Part 3

#### 3. List of Supporting Documents:

##### (1) NSMRL Reports

#### **NSMRL staff published the following reports:**

Santoro, T.P., and Wakefield, G.H., (2005). "Spatialized Auditory Displays for Passive Sonar Listening." NSMRL Technical Report #TR-1233. Groton, CT: Naval Submarine Medical Research Laboratory. Distribution authorized to U.S. Government agencies and their contractors.

Bing, M. N., America, A., Lamb, J., & Severinghaus, R. (2005). The prediction of submarine officer advanced course ascendancy from SUBSCREEN test scores. NSMRL Technical Report #TR-1238. Groton, CT: Naval Submarine Medical Research Laboratory. Distribution Unlimited.

Bing, M. N., America, A., Lamb, J., & Severinghaus, R. (2005). The prediction of submarine officer advanced course ascendancy from SUBSCREEN test scores: Addendum to NSMRL Technical Report #TR-1238 for Appendix D. NSMRL Memorandum Report #MR05-07. Groton, CT: Naval Submarine Medical Research Laboratory. Distribution Limited; Official Use Only.

Russotti, J.S., Creese, M.A., and Santoro, T.P. (2005). Advanced Binaural Sonar Audio Display Using Spatial Vernier Beamforming. NSMRL Technical Report #TR 1240. Groton, CT. Naval Submarine Medical Research Laboratory. Distribution Unlimited.

Bing, M.N., Panduranga, A. (2004). Analysis of the Subscreen Profile for an Alleged Double-Homicide Perpetrator: The Preexisting Condition of an antisocial Personality Pattern. NSMRL Memorandum Report #MR05-01. Groton, CT, Naval Submarine Medical Research Laboratory. Distribution Limited, Official Use Only.

Cudahy, E.A., Schwaller, D.W., Fothergill, D.M., Trapani, C.L. (2004). Quicklook Report: United States Coast Guard Impulse Systems Tests- Watergun. NSMRL Memorandum Report #MR05-02. Groton, CT, Naval Submarine Medical Research Laboratory. Distribution authorized to U.S. Govt. Agencies Only.

Cudahy, E.A., Schwaller, D.W., Fothergill, D.M., Trapani, C.L. (2004). Quicklook Report: United States Coast Guard Impulse Systems Tests – Airgun. NSMRL Memorandum Report #MR05-03. Groton, CT, Naval Submarine Medical Research Laboratory. Distribution authorized to U.S. Govt. Agencies Only.

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**Naval Submarine Medical Research Laboratory  
Groton, CT**

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The United States Submarine service has a long and proud tradition of developing and operating with leading edge technologies. The Naval Submarine Medical Research Laboratory (NSMRL) is a major contributor to integrating these technologies into submarine crew operations. NSMRL is DoD's Center for Undersea Biomedical Research. The laboratory's mission is to protect the health and enhance the performance of warfighters through submarine, diving and surface biomedical research solutions. Established in World War II to conduct mission critical studies in night vision, sonar sound discrimination, and personnel selection, NSMRL continues to serve the fleet by taking the lead in undersea human factors, sensory sciences and operational medicine.

Located on Submarine Base New London, Groton, CT, NSMRL researchers have access to three submarine squadrons in Submarine Group Two; the Navy Submarine School; the Naval Submarine Support Facility; Naval Undersea Medical Institute; and the Electric Boat Division of General Dynamics, which builds the nation's submarines. The laboratory is staffed by a diverse group of psychologists, audiologists, physicians, physiologists, and electrical, biomedical and nuclear engineers. Several colleges and universities are located in the same area, including the US Coast Guard Academy, Connecticut College, and the University of Connecticut.

NSMRL's accomplishments continue to be many and varied, and include scientifically based recommendations for submarine rescue procedures, submarine atmosphere limits, waivers for clinical medical conditions, advanced sonar system capabilities, diver/sonar safe distances, and symbology for visual displays.

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**NSMRL Scientists and Divers Touched by History**

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preservation project. This is a good example of Navy scientists and divers working side-by-side with working dive lockers and other government agencies to accomplish both research data collection and provide direct fleet support.

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A research team of scientists and divers dove into history when they collected research data as part of a preservation project for the USS ARIZONA memorial in Pearl Harbor, HI. The team worked with Mobile Diving and Salvage Unit 1 and the National Park Service, taking underwater noise measurements of a new hydraulic tool designed to remove samples of the battleship's hull for metallurgical analysis. The research team had two jobs to do, collect underwater noise levels as part of NSMRL's two-year comprehensive in-water noise survey project and determine the on-site permissible noise exposure level for the divers. Team members also performed working dives to assist in completion of the

### Diving and Environmental Simulation Department

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- The Diving and Environmental Simulation Department focuses on ways to optimize the safety and performance of Navy divers by investigating diver performance for a variety of environmental factors including sound exposure, thermal stress, and breathing gas conditions. Underwater noise can impact a diver through damage to hearing and internal organs, such as the lung and brain. Applied research includes reducing workplace hazards, providing underwater noise-protection tools and developing underwater force protection. A critical part of the program is the on-going direct fleet support regarding guidelines for operational limits due to underwater noise and direct support of the U.S. Navy's Force Protection efforts in diver deterrence/protection. These guidelines are developed directly from the basic research data collected by the laboratory.

### Submarine Medicine & Survival Systems Department

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- Submarine Medicine researchers focus on ways to optimize the health and job performance of undersea warfighters and reduce attrition and health impact due to psychological and physical conditions. The department includes the NAVSEA-sponsored Submarine Atmosphere Health Assessment Program.
- Survival Systems researchers conduct basic and applied research and development in the biomedical and bioengineering aspects of submarine casualties by developing equipment, procedures and guidance to optimize submarine disaster survival. The researchers serve as subject-matter experts on submarine rescue and escape for the operational fleet, policy makers and industry.

### Human Performance Department

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- Determining the operational viability of alternative watchstanding schedules for submariners could provide a biologically-based, circadian-friendly work/rest regimen that enhances alertness and performance while improving sleep efficiency. A study on an underway nuclear submarine will directly compare the alternative schedule's advantages over the current submarine watchstanding schedule, and what operational practices require modification to accommodate it.
- Hearing conservation focuses on ways to identify the early stages of noise-induced damage to the human ear to prevent noise-induced hearing loss (NIHL). Current research evaluates new methods to evoke otoacoustic emissions, an objective test considered sensitive to the early stages of—and susceptibility to—NIHL. The team's approach is to evaluate these methods in the laboratory for obtaining valid, reliable, and sensitive estimates of temporary noise-induced changes, and in the field using noise-exposed, at-risk personnel for detecting the early stages of permanent NIHL. The team also seeks to estimate the payoff from preventing hearing loss, by modifying the design of high-noise equipment and weapons, and in simulating the effects of NIHL on everyday activities.
- Ongoing research is developing unique auditory sonar displays that effectively double the distance of target detection by using the powerful technique of comparing interaural information, through novel beamforming techniques applied to existing hardware. Scientists also seek to optimize the quality of information presented to Navy submariners by creating an accurate, three-dimensional auditory representation of the undersea environment, and developing active noise-canceling binaural headphones. Combined, these display improvement strategies will help operators separate important from irrelevant information, reducing workload, and improving the identification, classification, and tracking of signals of interest, thereby elevating Situation Awareness.

### Achievements:

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| • Sea Lab I undersea habitat project  | • Studies of nitrogen narcosis   |
| • Development of the International Orange Color (Air-Sea Rescue Red)                            | • Effects of atmospheric constituents on health and performance in enclosed environments |
| • Disabled Submarine Escape and Rescue project  | • Pressurized Submarine Rescue Manual  |
| • Saturation diving and decompression tables  | • Data-based medical qualification policies  |
| • Hearing conservation in noisy environments  | • Farnsworth lantern for screening color vision  |
| • Safe exposure guidance for personnel in the presence of intense low and high frequency sonars | • Underwater acoustic signal discrimination and classification                           |
| • Enhanced underwater target detection and localization   | • Hearing loss modeling  |

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